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Review of the energy rating of dwellings in the European Union as a mechanism for sustainable energy

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Abstract

Reducing emissions of CO_2 and other GHGs is one of the biggest environmental challenges facing the European Union as it strives for sustainable development. If that challenge is to be met, domestic energy consumption must be controlled: it currently accounts for 40% of the total, making it one of the biggest sources of emissions. EU Directives 93/76 and 2002/91 make it compulsory for energy rating systems to be set up to report on consumption in buildings. This paper looks at the various rating systems now up and running, with varying levels of success, in EU countries. However, Denmark's is the only system that can be considered as providing a full energy rating in the sense of awarding a graded score to buildings rather than a simple pass/fail rating, and proposing ways of improving the score obtained. Indeed, many regulations on energy saving in the residential sector are extremely recent, and it is too soon to assess their results. In some States they may also be modified by reforms currently being studied or processed.

Keywords: European Union; Kyoto protocol; EU Directives; Energy rating; Dwellings

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1. Introduction

The main gas responsible for climate change is CO_2. The European Union has undertaken to reduce CO_2 emissions under the Kyoto protocol [1], but consumption is increasing year by year and we depend increasingly on supplies of oil and gas from beyond the borders of the EU. The Kyoto protocol undertaking to cut GHG emissions to 8% below 1990 levels by December 2008 requires us to reduce our consumption of oil, gas and coal.

In 2000, the European Commission approved a Green Paper [2] that established a strategy for tackling these two problems. Increased use of internal renewable energy sources would reduce emissions and energy imports, but all energy users must also make major efforts to reduce their own consumption.

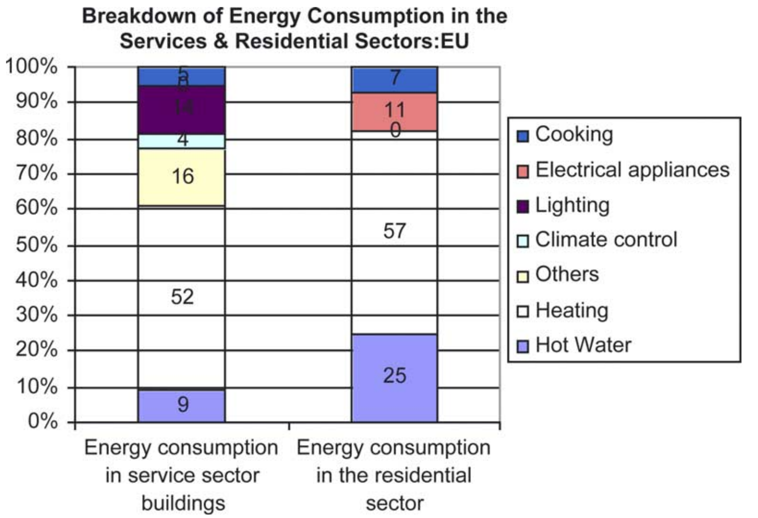


Fig. 1. Breakdown of consumption in buildings in the EU.

Transport and industry are major energy consumers, but in Europe buildings account for around 41% of all energy consumption (Fig. 1) [3], and that figure is growing year by year as standards of living increase and use of air-conditioning and heating becomes more widespread. It is calculated that there are around 10 million boilers over 20 years old in European homes: replacing them would result in a 5% cut in the energy used for heating. Moreover, between 30 and 50% of the energy used to light offices, commercial buildings and leisure facilities could be saved if more efficient technologies and systems were used. Air conditioning is being used more and more, but it is estimated that over half the energy it consumes could be saved if equipment compliant with stricter standards were used.

2. The Kyoto protocol

International concern about GHG emissions led to the Rio de Janeiro Convention of 1992 and to the Kyoto protocol. The Third Conference of the Parties to the Convention on Climate Change (COP3) took place on 1st–10th December 1997 in Kyoto, Japan. The previous conferences had been in Berlin (1995) and Geneva (1996). The various groups of countries attending undertook to reduce GHG emissions.

The EU as a whole undertook to reduce its emissions by 8% on 1990 levels by 2008–2012, the USA by 7%, Japan and Canada by 6%. Russia, Ukraine and New Zealand were to make no reductions and some countries, such as Australia, were to be allowed actually to increase their emissions. It was decided not to include additional undertakings for the Third World at this stage. On 31st May 2002, the 15 then Member States of the EU formally ratified the treaty, but it is now endangered at least in part because although 69 states from around the world have given their support, the US Congress has refused to

Table 1
Reduction of CO_2 emissions during the 1990s, Kyoto target and distance from that target for each Member State assuming that current trends are maintained

	Variation 1990–1999 (%)	Target 2008–12 (%)	Distance from target
Germany	−18.7	−21	−9.3
Austria	2.6	−13	8.5
Belgium	2.8	−7.5	6.1
Denmark	4	−21	13.5
Spain	23.2	15	16.5
Finland	−1.1	0	−1.1
France	−0.2	0	−0.2
Greece	16.9	25	5.7
The Netherlands	6.1	−6	8.8
Ireland	22.1	13	16.3
Italy	4.4	−6.5	7.3
Luxembourg	−43.3	−28	−30.7
Portugal	22.4	27	10.2
United Kingdom	−14	−12.5	−8.4
Sweden	1.5	4	−0.3
Total EU	−4	−8	−0.4

ratify the undertaking to which it signed up in 1997. This protocol is another weighty argument in favour of monitoring the energy consumption of buildings.

The 8% reduction on 1990 GHG levels to which the EU as a whole committed itself was an average: each Member State set its own emission reduction percentage according to its degree of industrialisation and current per capita per annum emission levels. These percentages vary widely from one country to another, ranging from 28% in Luxembourg to zero reduction on 1990 levels in Finland and France. Spain, Portugal, Greece, Ireland and Sweden were actually permitted to increase their emissions during this period.

Table 1 shows the data in the hands of the European Environment Agency concerning GHG emissions in 15 EU Member States between 1990 and 1999. The conclusion that can be drawn is that the EU as a whole is reducing its GHG emissions as established in the Kyoto protocol, but the overall average figure conceals big gaps between some States that are cutting their emission levels considerably (especially the UK and Germany) and others that are far from meeting the levels set in the agreement.

Throughout the years from 1990 to 1999, Spain recorded bigger increases in GHG emissions than any other EU member, with a 16.5 point deviation from the levels agreed in Kyoto. However, per capita per annum emissions in Spain are still less than the European average: the 7.9 ton of GHG per capita per annum produced in Spain in 1990 amounted to 69% of the EU average that year of 11.5 ton, while the 9.7 ton produced in 1999 amounted to 91% of the 10.7 EU average [4].

As elsewhere, CO_2 is the main culprit in Spain, accounting for 74% of all GHG emissions. A breakdown by sectors shows a spectacular increase in emissions from transport (up 45% from 1990 to 1999, compared to an 18% average increase in the EU). Emissions from industry rose by 29%, while in the EU they actually fell by 9% over the period.

3. The European legal framework

3.1. Directive 93/76/EEC (SAVE)

The European authorities had already taken steps to prevent the emission of greenhouse gases some years before the signing of the Kyoto protocol. In 1990, the Council of Environment and Energy Ministers agreed to take steps to stabilise total emissions of the main greenhouse gas, CO_2, at 1990 levels by 2000. In 1991, the Council approved the SAVE programme, whose aim is to promote a more rational use of energy and natural resources in EU countries.

September 1993 saw the passing of EU Directive 76/93 [5] intended to control and if possible reduce CO_2 emissions in the EU, promote the rational use of energy and natural resources and conserve the quality of the environment. This document marked the first official recognition on a European scale of the problem of assessing and rating energy use in buildings.

But Directive 76/93 does not specify what procedure must be used to rate energy use in buildings, or indeed what type of energy use should be assessed, so each State is largely free to interpret the regulation in its own way.

3.2. Energy performance of buildings: Directive 2002/91/EC

A proposal has now been put forward by the European Energy Commission for a new, specific directive on the energy rating of buildings (*Energy performance of Buildings, Directive 2002/91/EC 16* [6]), which seeks to unify criteria and apply a common method to calculate the energy performance of buildings throughout the EU.

This directive supersedes the directive on boilers (92/42/EEC [7]), the directive on construction products (89/106/EEC [8]) and the provisions of the SAVE programme concerning buildings, taking into account that the SAVE Directive on energy certification of buildings (Directive 93/76/EEC [5]) was passed in a pre-Kyoto context.

Member States must transpose the requirements of the new Directive on certification systems into their national legislations by January 2008 [9]. This Directive will have the following effects:

- To guarantee the application of minimum standards throughout the EU, a common method will be drawn up for measuring the energy efficiency of buildings. This method must take into account all the factors that condition energy consumption and will rate buildings in accordance with their characteristics, size and purpose (residence, office, school, etc.).
- Member States will set minimum standards of energy efficiency that will apply to both new buildings and large existing buildings (>1000 m^2) that undergo major renovation work.
- The points taken into account in rating the energy efficiency of a building include heat insulation, heating and air conditioning systems, natural ventilation and passive heating from the sun. Because of the wide range of climates found in Europe, local conditions and the environment are taken fully into account when calculating energy efficiency.

Some buildings, such as historic monuments, farm buildings and holiday residences may be exempt from compliance with regulations.

- A building certification system will emerge that will make energy consumption levels much more apparent to owners, tenants and users.
- There will be regular, compulsory inspections of boilers rated at more than 20 kW powered by non-renewable liquid or solid fuels. Boilers of this type rated at >100 kW must be inspected at least once every two years. For gas boilers the inspection period may be up to once every 4 years. Facilities heated by boilers rated at >20 kW which are more than 15 years old must receive a one-off overall inspection. The results of that inspection will serve to advise users on whether equipment should be replaced, and whether any modifications should be made. There will also be regular compulsory inspections of all air-conditioning equipment rated at more than 12 kW.

Estimates based on these measures envisage potential savings of up to 22% by 2010 [10] in energy for heating, climate control, domestic hot water and lighting. A sectoral breakdown follows.

- *Boilers*. The EU has 10 million boilers more than 20 years old. Replacing them would result in a 5% energy saving.
- *Lighting*. This accounts for 14% of total energy consumption by the service sector. Savings of 30–50% could be made by using more efficient components and better control systems and by incorporating other cutting-edge technologies.
- *Climate control*. Energy consumption by climate control is expected to double by 2020. Savings of 25% could be made by introducing minimum energy efficiency requirements.
- *Self-production and green energy*. Solar, biomass, co-generation, urban heating and cooling networks and heat pumps all reduce energy demand.
- *Bio-climatic design*. Active and passive solar systems, natural climate control and lighting can reduce energy demand by up to 60%.

4. What is energy rating?

Certification can be seen as an official recognition or distinction for good energy performance by a building. If certain energy-saving measures are not taken, certification is refused. This is the concept used in the USA, where the EPA (Environmental Protection Agency) awards its Energy Star to around 25% of buildings and domestic appliances (Fig. 2).

The key components of the certification process are generally the following:

- An inspection of the components of the building in the form of an audit or based on the blueprints.
- A report describing the performance of the building in energy terms, sometimes including proposals for improvements.
- In some countries, the allocation of a category or index number on a scale to enable the building's energy consumption to be compared to that of other buildings.

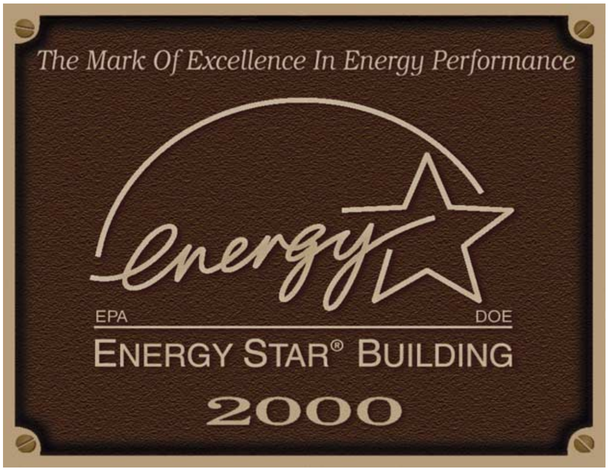


Fig. 2. Energy Star building certificate [www.energystar.gov].

Limitations of energy rating:

- Energy rating is always approached in relative rather than absolute terms. The final energy consumption of a building is assessed as an intermediate step in the rating process, but it cannot be used to draw conclusions on absolute energy consumption measured in monetary or energy units.
- The effectiveness of the rating therefore depends to all intents and purposes on the proper selection of the terms of reference. Those terms must take into account the freedom of the building designer in designing architectural aspects and installations. The rating must not therefore punish design components, but must be merely a skin-deep analysis. Similarly, it should say nothing of whether one system is better than another, but should merely assess the quality of the equipment involved in each case.
- This relative nature of the rating means that it is applicable only to buildings with certain shared features and types, e.g. it is useful in subsidised public housing and similar buildings.
- It is valid only for a limited time: although many features of the exterior of a building can be regarded as permanent, the energy performance of its installations will decrease over time unless it is checked and renovated regularly. The skin of the building itself may also undergo modifications, all of which may result in a drop in its rating as time goes by. There is therefore a need for action by the authorities in the form of a further rating to ensure that the energy performance that earned the building its initial rating is maintained.

5. Current situation in EU member states

The Member States of EU-15 have established compulsory maximum heat transmission coefficients for new buildings, though there are big differences between

them in regard to the actual minimum heat insulation levels required. More insulation means less energy loss, and indirectly less GHG emissions. The 10 new Member States of EU-25 are lagging well behind, as we shall see in Section 5.15 below.

For the moment, however, few EU States have gone further than this in their legislations. Austria, Spain, Finland, Greece, Portugal and Sweden currently have no official building energy rating system in place, and the method used in Belgium, Italy and Germany is not much more than a somewhat more sophisticated variation on the regulations governing minimum insulation requirements for outer walls, as it gives no information on anything other than heat transmission coefficients. In the case of Germany, however, this is mitigated to some extent by a system of subsidies for buildings that use renewable energy sources or make improvements that foster energy saving.

That leaves six States that do have more complete energy rating systems, which take into account not just building insulation but also heating, hot water and climate control systems and thus cover overall energy consumption by buildings. Those States are Denmark, the UK, France, The Netherlands, Ireland and Luxembourg. A more detailed look at the measures implemented in each of these States follows.

5.1. Denmark

Denmark pioneered energy rating in the EU, making it a reference point for other Member States. It has been awarding subsidies to individuals for energy saving measures since 1981, in 1985, it introduced a compulsory inspection prior to the sale of dwellings, and in 16th June 1996 it passed the 'Act on Promotion of Energy and Water Conservation in Buildings' [11], which came into force on 1/1/1997 [12,13].

This Act establishes different types of energy audit: ELO (energy certificates for large buildings), EM/EK (energy certificates for small buildings) and certificates for industrial buildings (study of CO_2 in industry).

Certification is compulsory for all non industrial buildings, including both the residential and services sectors, old and new, private and public buildings. Only buildings with extremely low energy consumption levels and those used for production are excluded.

The rating system is based on an energy audit carried out by a qualified specialist (normally an architect or engineer) prior to the sale of the building. The information obtained in this audit is split into three parts (Fig. 3).

The first part comprises a standard energy rating on a scale ranging from A1 (maximum efficiency) to C5. This rating reports on water and energy consumption and CO_2 emissions, and makes a comparison with other similar buildings. It also reports on the total expected consumption per annum of water and energy for a 25-year period. These calculations are drawn up for the normal conditions of use of the building: the aim is to make owners more aware of how much energy they are consuming and of how much it costs.

The second part is an energy plan, with proposals for savings in all types of energy used in the building, and in water. This plan also includes an estimate of the investment needed, the annual savings and the technical lifetime of each proposal.

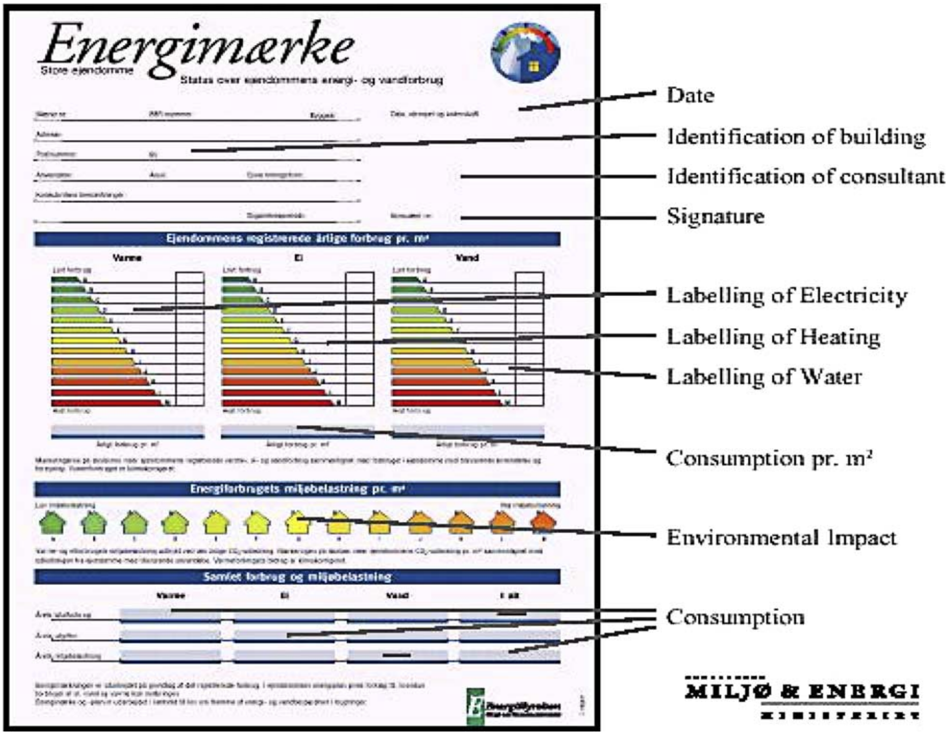


Fig. 3. Danish energy rating form [13].

The third and final part of the document provides information on the current state of the building, on its heating system, on energy use by the owner, on the size of the dwelling, on the price of energy, heating, etc. to provide supporting evidence for the rating and energy plan.

The Danish Energy Agency, run on a budget funded by the state, promotes and runs this system. The almost 800 energy consultants who perform the audits, most of them architects and engineers, are required to have at least 5 years' experience in the study of buildings and energy saving. They are given a training course and receive updated information four times a year on developments in the rating system.

The cost of rating single-family dwellings, which ranges from 300 to 500 euros, must be borne by the home-owner. Owners who disagree with the rating awarded to them can appeal to the Small Building Energy Rating Council. The reliability of the ratings awarded is monitored by re-inspecting a random selection of buildings. If the results of this second check fail to coincide with the initial rating, the consultant may lose his/her accreditation or even be required to answer for any financial loss that an incorrect rating may have caused the owners.

The results to date for the energy rating of small buildings are fairly encouraging. Between 45,000 and 50,000 ratings per year are carried out, almost 70% of single-family dwellings are rated at the time of sale, and spending on energy in single-family dwellings has dropped by around 20%.

5.2. Italy

In Italy, the relevant measure is a Ministerial Decree dated 2nd April 1998 [14], based on Article 32 of the Regulation for the Implementation of the 1991 National Energy Plan in regard to the rational use of energy, energy saving and the development of renewable energy sources. This measure specifically covers the manufacture of materials for building construction.

In terms of energy saving this decree, which came into force in May 2000, only covers transparent or translucent outer skins with an overall conduction coefficient of less than $5\,W/m^2\,K$, and even then only looks at three characteristics: air-tightness, light transmission and heat transmission. The insulation of their skins is therefore the only energy aspect of buildings currently regulated by law in Italy. However, the Italian Heat Committee concluded the first stage of a study in April 2001 with a view to establishing regulations on energy rating for buildings [15]. This first stage covers only residential buildings and energy consumed by heating and hot water systems, not including electricity or climate control in summer. Service sector buildings will be covered by the future second stage of the project. The Committee has deemed it necessary to draw up new UNI standards to cover energy rating regulations. Constructors will be required to provide a declaration attesting to the characteristics and energy performance of the outer skins of buildings (Fig. 4).

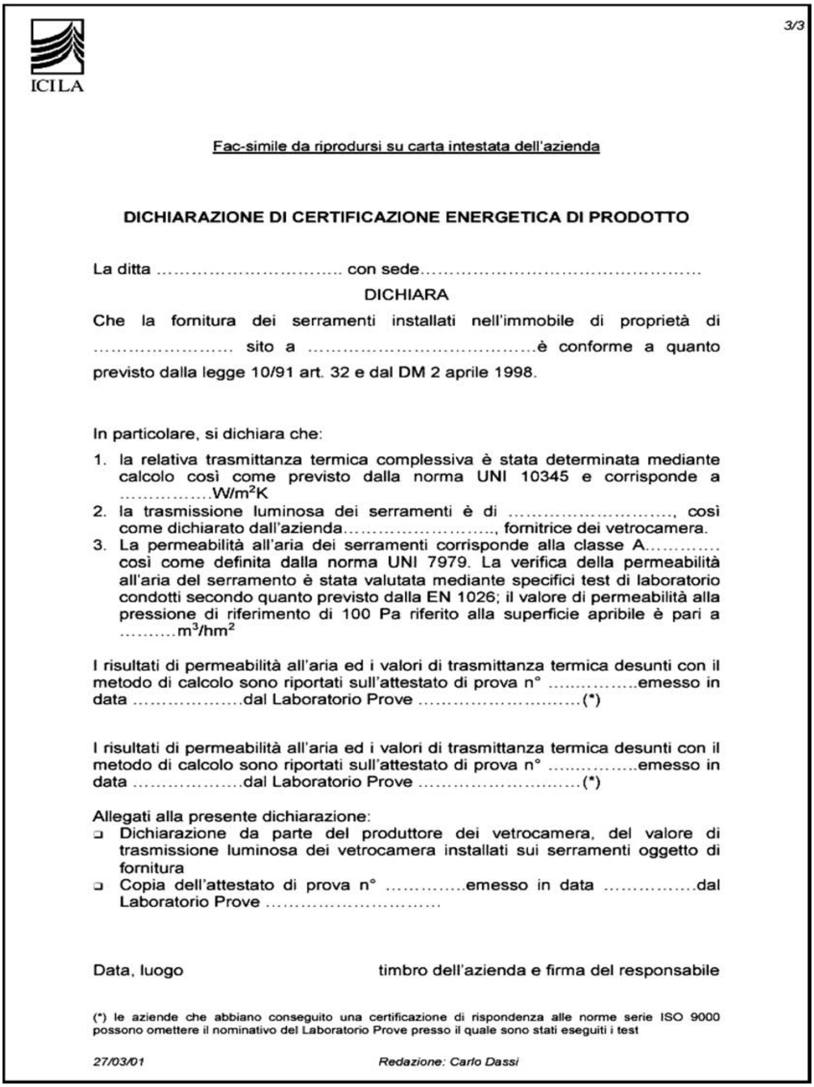
5.3. Germany

The relevant legislation in Germany is the Energy Saving Decree approved by parliament in the summer of 2001, which applies to all new buildings other than underground or temporary buildings and those intended to house animals or plants. It also applies to old buildings on which improvement work is done [16].

For new buildings and renovated old building, energy consumption is limited to 7 l of oil per annum per square metre occupied, 30% lower than under the earlier Heat Conditioning Decree of 1982.

Energy rating is to be compulsory, and will include information on the energy characteristics of buildings. Calculations will be based on the limit levels for heat insulation and heat transmission coefficients required for buildings under the regulations already in force. Certificates will be drawn up and awarded by energy assessors, and will be shown to prospective tenants of the dwelling. Subsidies will be granted to buildings that obtain at least 70% of their energy from renewable sources.

For old buildings, a voluntary renovation plan has been drawn up to fund measures to reduce CO_2 emissions from dwellings. These measures include improving heat insulation, replacing windows, improving or replacing heating systems (except for the compulsory replacement by the end of 2006 of boilers dating from before October 1978) and building energy diagnoses. The funding allocated to the programme is 200 million euros per annum. These measures are voluntary, with the exception of the compulsory replacement of boilers alluded to above.



ICILA 3/3

Fac-simile da riprodursi su carta intestata dell'azienda

DICHIARAZIONE DI CERTIFICAZIONE ENERGETICA DI PRODOTTO

La ditta .... con sede..

DICHIARA

Che la fornitura dei serramenti installati nell'immobile di proprietà di .... sito a ....è conforme a quanto previsto dalla legge 10/91 art. 32 e dal DM 2 aprile 1998.

In particolare, si dichiara che:

1. la relativa trasmittanza termica complessiva è stata determinata mediante calcolo così come previsto dalla norma UNI 10345 e corrisponde a ....W/m^2K
2. la trasmissione luminosa dei serramenti è di ...., così come dichiarato dall'azienda.........................., fornitrice dei vetrocamera.
3. La permeabilità all'aria dei serramenti corrisponde alla classe A............ così come definita dalla norma UNI 7979. La verifica della permeabilità all'aria del serramento è stata valutata mediante specifici test di laboratorio condotti secondo quanto previsto dalla EN 1026; il valore di permeabilità alla pressione di riferimento di 100 Pa riferito alla superficie apribile è pari a ....m^3/hm^2

I risultati di permeabilità all'aria ed i valori di trasmittanza termica desunti con il metodo di calcolo sono riportati sull'attestato di prova n° ....emesso in data ....dal Laboratorio Prove ....(*)

I risultati di permeabilità all'aria ed i valori di trasmittanza termica desunti con il metodo di calcolo sono riportati sull'attestato di prova n° ....emesso in data ....dal Laboratorio Prove ....(*)

Allegati alla presente dichiarazione:

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- ❑ Copia dell'attestato di prova n° ....emesso in data ....dal Laboratorio Prove ....

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Fig. 4. Italian energy rating certificate [15].

5.4. United Kingdom

The relevant regulation is the SAP (Standard Assessment Procedure), which has been in force since 1995 [17] (Fig. 5).

The SAP was drawn up by the British authorities to calculate the energy rating of residential buildings. It is compulsory for new buildings. It is based on the annual cost of energy for heating and hot water per square metre of surface area. A number of factors affecting energy efficiency are taken into account, including heat insulation on the outer skin of the building, the regulation and efficiency of the heating and hot water systems,

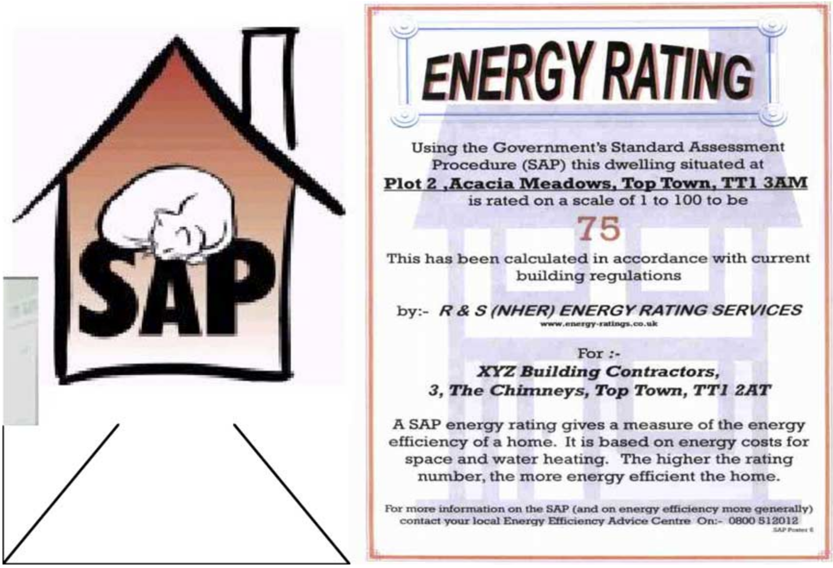


Fig. 5. British building energy rating certificate [17].

the solar gain of the building and the type of fuel used to produce heat and hot water. Inspectors must receive a training course and pass an examination.

The data obtained are entered on a spreadsheet. SAP ratings can range from 1 to 100, and the scale used is logarithmic: a one-point increase in the rating corresponds to a predetermined percentage of reduction in spending on energy and not to a fixed amount, as would be the case with a linear scale such as that used for the energy rating of domestic appliances. If the rating is below a certain level, more insulation is required. Buildings that score 80 points or more are considered to be of high quality. A good SAP score is considered sufficient proof that a building complies with regulations on insulation.

SAP ratings do not take into account the location of the building (two buildings with the same design in different areas of the country would have the same SAP rating). They do not consider other elements such as lighting and domestic appliances, nor do they add recommendations on how to make homes more energy-efficient.

The problem in the UK is that energy rating is aimed purely at the market: there is a lack of incentives from the government and through legislation. Only new residential buildings (and renovated buildings) have to undergo SAP to comply with building standards, and the results of the assessment must be passed on the purchasers [18,19]. There is no legislation concerning buildings already occupied. There is a debate ongoing concerning the possibility of requiring energy ratings when a home is sold, and concerning who such pay for such ratings.

By mid 2001, 600,000 new buildings and 300,000 renovated ones had been assessed, and it is estimated that assessment is proceeding at 170,000 homes per annum. The total number of homes in the UK is around 16 million. Three million of the 5 million council houses in the UK have already been rated.

5.5. France

The relevant legislation is Decree 2000-1153 of the Ministry of Housing and Transport of 29th November 2000 [20–22]. It applies compulsorily to newly constructed non industrial buildings with construction permits dating from 1st June 2001 onwards. The energy consumption (C) in kW h of such buildings on heating, hot water, ventilation, climate control and, in some cases, lighting, must be no higher than a reference level (Cref). This is an overall coefficient, so it is possible for instance to offset the negative effect of windows without climate control (provided the heat transmission limit level is not exceeded) by improving the heating system.

To comply with energy standards, the inside temperature must be no higher than a set reference temperature. Limits are also set for heat insulation in all outside walls and spaces, for the level of humidity in the air produced by ventilation systems, for regulating heating and cooling in domestic hot water accumulator systems. Reference limits vary from region to region. However, the regulations do not consider the orientation of outside walls and spaces, or the ratio of exposed surface area to building volume.

Two methods may be used to calculate whether a building complies with the regulations: the first is a precise, complex method intended for use by technical building specialists, and the second is a simpler method intended for people who are not experts in heat-related matters, and even for private individuals. This second method has its limitations: it applies only to buildings with a surface area of less than 220 m^2 which are not climate-controlled, which have internal but not external insulation which use materials that meet certain requirements.

For winter the simplified method involves assessing the insulation of the outer skin of the building at a series of points, checking for heat channels, assessing the insulation of windows and spaces, the heating and domestic hot water systems, the ventilation system and, in parts of the country with a milder climate, three or four other points. The total score must be at least 18 to comply with the regulations.

For summer, the simplified method consists merely of requiring class A or B protection, depending on the region. These classes of protection involve a pre-set solar factor for windows and a pre-set thickness for outside walls (Fig. 6).

5.6. The Netherlands

The relevant regulation for old buildings is EPA (Energie Prestatie Advies—‘energy performance study’), which has been in force since January 1st 2000 [23]. For new buildings it is EPB (standing for ‘standard energy performance’), though this is not a compulsory regulation.

EPB, which was first developed in 1995, calculates the total energy consumption of newly constructed buildings, and establishes an annual maximum equivalent to 1000 m^3 of natural gas per home.

EPA was drawn up to provide an overall energy study of existing buildings and encourage owners to take steps to save energy. It looks at energy consumption resulting from heating, hot water, lighting and the operation of pumps and fans. Lighting demands per person are worked out using standard figures once the surface area and number

Récapitulatif pour la thermique d'hiver

	Nombre de points
Isolation des sols, des murs et des toitures	
Ponts thermiques	
• plancher haut	+
• plancher intermédiaire	+
• plancher bas	+
• refends	-
Portes et fenêtres	+
Système de chauffage et de production d'eau chaude sanitaire	+
Système de ventilation	+
Lieu de construction	+
TOTAL***	=

* La pose d'une chape flottante permet l'attribution de points dans les conditions prévues au paragraphe 2.1
** Les maisons chauffées à l'électricité doivent être équipées d'un conduit de fumée dans les conditions définies par un arrêté
*** Rappel : le total des points obtenus doit être égal ou supérieur à 18

Fig. 6. Simplified method for assessing compliance with energy rating requirements in France [22].

of occupants are known. Various energy-saving measures are considered, and the effectiveness of each is assessed using an energy saving index. For now this method is used only in residential buildings, but another system is being developed for industrial buildings.

EPA is not an official certificate, though it does inform home-owners of subsidies that may potentially be granted for work to improve the energy performance of their homes. It is an independent procedure not directly linked to state aid, but there is a subsidy available to anyone who has an EPA conducted and then makes changes on the basis of the advice obtained in it. If the review of EPA scheduled for 2004 reveals that the expected results have not been attained, the system will become compulsory.

5.7. Belgium

The relevant legislation can be found in standards NBN B62-002 and NBN B62-004, which have been in force since 1987 [24]. These regulations are compulsory for all new residential buildings. In Brussels and the Walloon region, they are also compulsory for all other new non-industrial buildings.

The limit coefficient for new residential buildings is K55, i.e. they are required to have an average heat transmission coefficient of no more than 0.55 W/m^2 °C. As well as the overall coefficient for the building as a whole, upper limits are also set for some outside walls.

For new buildings intended for non industrial service use the legislation varies from region to region. In the Walloon Region and in the capital Brussels the coefficient applied is K65, i.e. an overall average heat transmission coefficient of no more than 0.65 W/m^2 °C,

and there are also limits on transmission through certain walls that must not be exceeded. In Flanders, the K55 coefficient applies to all new service-sector buildings as well as to residential ones.

5.8. Ireland

The relevant regulations are Heat Energy Rating (HER) and the Energy Rating Bench Mark, (ERBM), set up in 1997 and 1992, respectively, to monitor compliance with the 1992 building regulations [25]. They can be applied voluntarily to new buildings, and the ERBM can also be applied to existing buildings (Fig. 7).

The Energy Rating Bench Mark, developed by the National Irish Centre for Energy Rating, is the country's most widely used energy rating system. It is used voluntarily by builders and fuel suppliers to promote low-consumption buildings. It reports on energy consumption per square metre per annum, and on CO_2 emissions per annum, thus taking into account the performance of the systems installed in buildings. It is not an official certificate, but it does include recommendations on improving outside walls, on heating systems and fuels, and information on the savings that such improvements would bring about.

5.9. Luxembourg

The relevant legislation is the Grand Duchy Regulation on Buildings, which has been in force since 1996. It applies to all new and existing service-sector buildings, but is not compulsory. The Luxembourg authorities have been organising energy audits



Fig. 7. Irish energy rating certificate [25].

at residential and commercial buildings since 1996. Such audits are carried out by specialists authorised by the Energy Ministry. The authorities subsidise 50% of the cost of the audit, up to a maximum amount, when owners implement reforms proposed by the auditor.

In spite of the voluntary nature of the inspections, the result seems to have been quite satisfactory in the residential sector. There is little renting of homes in Luxembourg: 75% of homes are owner-occupied. This means that home-owners are the first to have an interest in making their homes energy-efficient, since it is they who will benefit from energy savings. The current system is expected to continue until 2006.

5.10. Spain

The first measure taken in Spain to reduce energy consumption and provide state support for the creation of R&D programmes for energy sources not requiring the use of oil came with Decree 1490/75 of 12th June 1975 [26]. For the moment, the only official regulation in this field is the RITE [27] (Regulation on Heat Installations in Buildings), which refers back to the NBE-CT-79 (Basic Building Regulation on Heat Conditions of 1979). This regulation divides Spain into various climate areas, and sets a maximum overall heat transmission coefficient (Kg) for buildings in each. It also indicates how that coefficient is to be calculated.

The General Directorate for Housing, Architecture and Urban Planning of the Ministry of Infrastructure and the Institute for Diversification and Saving of Energy (IDAE) [28] of the Ministry of Industry and Energy signed a co-operation agreement on 28th November 1997 to update the NBE-CT-79 and develop an energy rating process.

Initially this energy rating system will apply only to homes that can be classed as 'publicly subsidised housing' (in Spanish Viviendas de Protección Oficial). Such homes will be rated on a scale of 1–10 from low- to high-energy consumption. The rating will be awarded following an assessment of the insulation of the outside walls and the performance of heating and hot water systems. This assessment will be conducted using a database of buildings in representative areas of the different climate areas and energy-saving data calculated with energy-simulation IT programs.

5.11. Austria

Austria is a federal state, so each of its nine regions or Länder has its own regulations. There is a nation-wide agreement on energy efficiency that establishes standards for regulating heating systems and building structures, but the regional governments draw up their own heat requirements in terms of the heat transmission coefficients (U) required of the different outside walls of buildings in some cases, or for whole buildings in others. The regulations apply only to new buildings. Major subsidies are available for the renovation of old buildings, including aid to replace windows and antiquated heating systems. Incentives are provided especially for the use of systems that run on solar or biomass energy.

5.12. Sweden and Finland

Swedish legislation establishes minimum insulation requirements for different parts of buildings [29]. The requirements are not specific, but call for certain overall heat performance levels to be attained. Finland's regulations are quite similar, though they apply not only outside wall insulation coefficients but also the renovation of indoor air and ventilation systems. The Finnish Environment Ministry is also reviewing national building legislation to improve the energy efficiency of new buildings.

5.13. Greece

Until recently, the Greek authorities merely assured the heat insulation of buildings. However, in 2001, a plan of action was drawn up to bring matters into line with European Directive 93/76 on carbon dioxide emissions. This plan envisages financial incentives for energy-saving measures in buildings in the interim while new regulations are being prepared that will include minimum energy requirements for new buildings along with other measures such as energy audits, classification of buildings according to energy consumption, etc.

5.14. Portugal

In Portugal, efforts are still required more in guaranteeing comfort levels for heat in buildings rather than on promoting energy saving or reducing CO_2 emissions. The RCCTE [30] (Regulations on the Heat Performance Characteristics of Buildings) is relatively recent: it dates from 1991, while the equivalent Spanish regulations were introduced in 1979. These regulations set limits on the demand for heating, cooling and the heat properties of all elements of the outer skins of buildings. To that end buildings must either meet requirements such as minimum heat insulation coefficients for outer walls and maximum solar factor levels for glass, or calculate heating and cooling needs and confirm that they do not exceed the limits set for the climate area where the building stands.

5.15. New member states of EU-25 [31–33]

Slovakia. Ministerial decrees were enacted in 2002 on energy efficiency and renewables, to establish labelling for domestic appliances with a view to increasing energy efficiency.

Slovenia. Legislation was enacted in 2002 to set prices for energy production. The decree implementing this energy legislation sets rules and principles applicable to contracts between energy producers and grid managers. Slovenia has also set up the necessary administrative institutions: an energy body, a body working on the rational use of energy, a body to take charge of oil product reserves and a nuclear safety authority.

Estonia. Estonia signed the Kyoto protocol in December 1998. Accordingly, it must increase the energy efficiency of the relevant sectors of its national economy. The Estonian government passed a national energy conservation programme in January 2000.

Hungary. July 1999 saw the passing of a long-term energy strategy that laid the basis for establishing a suitable framework in energy matters. Hungary has launched a programme to favour energy efficiency whose main goals are to encourage the use of renewable energy sources and to increase public awareness of energy problems. Hungary has a nuclear safety authority, a council for the conciliation of interests on energy matters, an energy centre in charge of energy performance and an independent grid manager. It is also a participant in the SAVE II Community programme to foster energy saving and in the JOULE-THERMIE programme.

Latvia signed the Kyoto protocol in 1998, and ratified the protocol on energy efficiency and related environmental aspects of the Energy Charter in October that same year. March 1999 saw the passing of a law protecting consumers' rights that includes provisions on labelling. In November 2000, the government approved a national energy performance strategy, and in January 2001, a set of measures were introduced to implement that strategy. Legislation passed in 2002 seeks to promote the use of renewable energy sources and nation-wide production of heat and electricity in combined-cycle facilities.

Malta. In February 2001, the Maltese government passed a law on product safety covering labelling standards and energy efficiency. This was intended to encourage the use of renewable energy sources, but apart from tax deductions in VAT on solar energy Malta has introduced no measures to foster energy saving and renewables.

Poland. In February 2002 the Polish government passed a document under the title 'Major guidelines on national energy policy for 2000–2020'. This marked a big step forward in that it laid down the main goals for preparing the energy sector for accession to the EU. Poland has set up an energy efficiency centre, but its energy efficient levels remain very low in comparison with the EU average. Poland is taking part in the SAVE II Community programme for the promotion of energy efficiency.

Czech Republic. January 2001 saw the entry into force of new legislation to regulate the market and cover various technical aspects of the energy sector. In the field of energy efficiency the government has established an initial programme of public-sector aid for energy saving and the use of renewables based on the national programme for rational energy management and the use of renewable energy sources. The country is taking part in the SAVE II Community programme for the promotion of energy efficiency.

Lithuania has designed a plan of action to implement the national energy strategy adopted in 1999. It has gradually increased its energy efficiency and has adopted a programme on energy efficiency and renewables for 2001–2005.

Cyprus. A plan of action on energy efficiency and renewable energy sources submitted to the Council of Ministers envisages incentives to encourage photo-voltaic, wind, solar heat, biogas and other energies.

6. Comparison between member states

The foregoing review of legislation on energy saving in buildings in EU Member States shows that their governments are increasingly interested in bringing down CO_2 emissions from this sector, but that regulations on this matter have only just begun to take shape.

All 15 of the Member States prior to the expansion of May 2004 have introduced compulsory maximum levels for heat transmission coefficients in new buildings, but a look at their regulations on heat insulation reveals big differences, even after allowances are made for differences in climate to enable a comparison to be drawn using a method known as 'degrees per day' (the sum of the differences between the temperatures at each location and those of a reference location, used as an indicator of the mildness or severity of the climate). After adjusting the figures in each case to take climate into account we took Danish regulations and applied them to each Member State. Consumption measured using the Danish model is sometimes much lower than the figures obtained via national heat insulation regulations.

Fig. 8 shows energy consumption in Member States as calculated under their national regulations, compared with the figures obtained using the Danish system adjusted for differences in climate.

More insulation means lower energy losses, which in turn means bigger savings and, indirectly, lower GHG emissions. However, for the moment few EU Member States have taken their legislation any further, and indeed Austria, Spain, Finland, Greece, Portugal and Sweden have no official building energy rating system. Moreover, the rating system in used in Belgium, Italy and Germany seems to be no more than a somewhat more sophisticated version of the regulations on minimum insulation requirements for outside walls: neither the Belgian K55 and K65 coefficients nor the Italian energy certification declaration gives any information on heating and hot water systems, on final energy consumption or on anything other than transmission coefficients. Although the German energy rating system also falls short in this area, its shortcomings are palliated in part by a system of subsidies for buildings that use renewable energy sources and those that make improvements that favour energy saving. That leaves six Member States that do have a more complete energy rating system that covers not only building insulation but also heating, hot water and climate control systems, and therefore overall energy consumption in buildings.

Even so, only the Danish system can be considered to be a complete energy rating system, understood as one which awards a score to buildings on a scale, provides more information than a mere pass/fail grade and proposes alternatives for improving the score obtained. France meets neither of these requirements. Apart from Denmark, only the UK

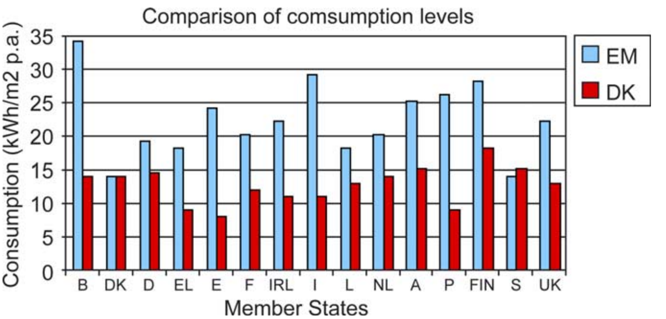


Fig. 8. Comparison of consumption measured as per Danish regulations in buildings in EU Member States (adjusted for climate differences) MS: consumption according to Member States, DK: consumption according to Denmark.

Table 2
Comparison of regulations on energy rating in the Member States of EU-15

	D	A	B	DK	E	FIN	F	GR	H	IRL	I	L	P	GB	S
Regulations on outside wall insulation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Compulsory ERS in new EdiL	X		X	X			X				X			X	
Compulsory ERS in renovated EdiL	X			X											
ERS regulating non residential buildings in service sector	X		X	X			X			X	X	X			
ERS assessing energy consumption				X			X		X	X		X		X	
ERS with rating scale				X										X	
ERS indicating possible energy improvements				X					X	X		X			

ERS, energy rating system.

has a scale for gauging the quality of buildings in terms of energy saving, but the only compulsory system in the UK is SAP, which gives no guidelines as to possible improvements. Such guidelines are given by the new rating systems in The Netherlands, Ireland and Luxembourg, but they have the drawback of not being compulsory.

7. Conclusions

The foregoing review of legislation on energy saving in buildings in EU Member States shows that their governments are increasingly interested in bringing down CO_2 emissions from this sector, but that regulations on this matter have only just begun to take shape.

However, the quality of legislation on paper must not be confused with the actual results obtained: the fact that good regulations exist does not mean that they are always complied with. And on the other side of the coin, the fact that a system is not compulsory does not mean that it is not widely used or that it does not lead to major energy savings. Moreover, many of the regulations on energy saving in the residential sector are very recent, and it is too early to assess the results. In some States, regulations may also be modified by reforms currently being considered or implemented. Bearing all this in mind, Table 2 summarises the differences and similarities between the energy rating systems used in the Member States of EU-15.

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